§7. Physics Study on 3-D Helical Equilibrium Plasmas with 2-D Imaging Diagnostics

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The measurement of bremsstrahlung soft X-ray (SXR) radiation is one of the useful passive methods for diagnosing high-temperature plasmas, because contours of the SXR emissivity correspond to magnetic surfaces of the plasmas. SXR imaging has been applied to high-temperature toroidal plasma experiments for the study of pressure fluctuations either in the core or at the periphery[1]. The reversed field pinch (RFP) is a high-temperature and high-beta toroidal plasma. In the RFP, studies on the behavior of magnetic islands due to the tearing modes are quite important, because the RFP configuration is self-organized and sustained by nonlinear interaction of the tearing modes, which lead to magnetic chaos. One of the important issues of this study is the development of three dimensional (3-D) SXR measurement system, which will be applied for physics study on 3-D helical equilibrium on LHD.

Consecutive imaging measurement has been a useful tool for understanding the plasma dynamics and instabilities. Therefore, we have developed an SXR imaging diagnostic system that uses multiple pin-hole SXR cameras together with high-speed cameras to record the time evolution of the SXR images from the tangential[2] and vertical directions simultaneously for studying the dynamic structures of 3-D SXR emissivity. A schematic drawing of the imaging system set on low-aspect-ratio RFP RELAX[3] is shown in Fig. 1.

Figures 2 show the dependence of vertical (a), (b) and tangential (c), (d) SXR images on reversal parameter F. While, in vertical image, zonal structure becomes to be tilted as F becomes lager. In tangential image, while, a filament structure clearly appears in shallow reversal discharge. Comparing with calculated images assuming Multi-Helicity (MH) (e) and QSH (f) states, we may conclude the structures in shallow F suggest helical SXR emissivity distributions associated with internal tearing mode. This result is consistent with F dependence of mode spectrum obtained from edge magnetic probes. This analyses would deepen our understanding of the helical transion phenomena in high-beta fusion plasma.

1) S. Ohdachi *et al.*, Plasma Fusion Res. **2**, S1016 (2007)

2) A. Sanpei *et al.*, IEEE Transaction Plasma Science, **39**, 2410 (2011).

3) S. Masamune *et al.*, 24th IAEA Fusion Energy Conf., EX/P4-24 (2012).

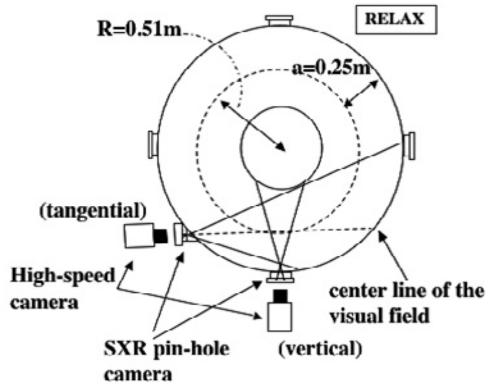

Fig. 1: Arrangement of the SXR pin-hole camera and the high-speed camera.

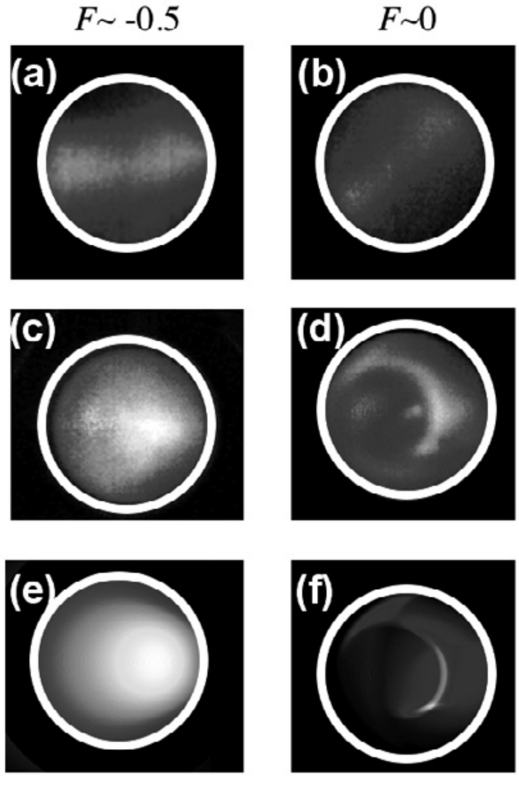

Fig. 2: Typical experimental SXR images (a), (b) obtained from vertical port, and (c), (d) obtained from tangential port in RELAX with a time resolution of 100 kfps, respectively. (e) and (f) are calculated tangental SXR images corresponding to MH and QSH state, respectively.